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**Aseptic revision knee arthroplasty with total stabilizer prostheses achieves similar functional outcomes to primary total knee arthroplasty at 2 years: a longitudinal cohort study**

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# **Aseptic revision knee arthroplasty with total stabilizer prostheses achieves similar functional outcomes to primary total knee arthroplasty at 2 years: a longitudinal cohort study**

## **ABSTRACT**

### **Background**

Patient function is poorly characterised following revision total knee arthroplasty, though is generally accepted to be inferior to that following primary procedures.

### **Methods**

53 consecutive aseptic revisions to total stabilizer devices were prospectively evaluated, pre-operatively and at 6, 26, 52 and 104 weeks post-operatively, using the Oxford Knee Score (OKS), range of motion, pain rating scale, and timed functional performance battery. Data was assessed longitudinally and in comparison to primary TKA data with identical outcome assessments at equivalent time points.

### **Results**

Mean outcomes changes were; 13 point increase in OKS (from 17.5 (SD 7.4) to 32.4 (7.9) points); 21 degree improvement in flexion (80.6 (20.5) to 101.5 (13.2) degrees); 60% reduction in pain report (7.7 (2.3) to 1.3 (0.4) points); 15 second improvement in timed performance assessment [47.2 (19.1) to 32.0 (7.0) seconds ( $p < 0.001$ ). No difference was seen between primary and revision cohorts in OKS or pain scores (ANOVA,  $p=0.2$  and  $0.19$ ). Knee flexion and timed performance assessment were different between primary and revision groups (ANOVA,  $p=0.03$  and  $p=0.02$ ) however this was due to differing pre-operative values. The revision cohort achieved the same post-operative scores as the primary cohort at all post-operative time points.

### **Conclusions**

Patients undergoing revision TKA for aseptic failure with total stabilizer implants made substantial improvements in the initial 2 years following surgery in both patient reported and directly assessed function, comparable to that achieved following primary knee arthroplasty.

### **Key Words**

Revision Knee Arthroplasty, Patient Outcomes, Function, Performance

**INTRODUCTION:**

Rates of revision total knee arthroplasty are rising through an increase in the volume of primary procedures performed, increased population longevity and that younger patients are being offered joint arthroplasty than was previously the case[1]. This increase in revision rate is expected to continue, with growth of 600% predicted in revision TKA between 2005 and 2030[2].

The cost of revision surgery is substantially greater and utilises greater hospital resources than primary procedures. In addition to lower survival rates and greater complication rates, it is generally accepted that outcomes following revision arthroplasty are inferior to those following the primary procedure[3]. Around 20% of revision cases address infection of the primary implant. These cases are typically more difficult to address, often requiring multiple operations and adjunct therapies. Conversely, approximately 80% of revision cases are aseptic and more readily addressable in a single surgical episode. In this latter situation, modern semi constrained implant designs are suggested to offer high levels of function, but with the ability to accommodate significant bone loss.

Unfortunately there is a general lack of good quality data available with which to assess the functional outcomes of revision knee arthroplasty; the data that is available tends to focus on survival and surgical complications or comes from studies conducting registry reviews of patient reported outcomes metrics[4]. Specifically, direct linked longitudinal assessment of physical function in patients undergoing revision knee replacement is lacking in the orthopaedic literature.

The primary aim of this study was to chart patient reported and functional outcomes in the initial two years following aseptic revision TKA using semi constrained total stabilizer implants. A secondary aim was to contextualise these data by comparing to existing (published) data for primary TKA.

**PATIENTS AND METHODS:**

Following local ethical approval, we prospectively assessed consecutive aseptic revision total knee replacements using total stabiliser implants (Triathlon TS, Stryker) performed at a single UK orthopaedic teaching hospital over a 2 year period between 2010 and 2012. The study centre is the only hospital receiving adult referrals for a predominantly urban population of approximately 850 000 people.

Patients were identified from the planned operation lists of 4 consultant orthopaedic surgeons. All procedures were revision of a primary implant to a total stabilizer device. Surgery was conducted using standardised instrumentation and surgical technique of joint line restoration with posterior referencing. All components were cemented. Local standards of care and post-operative protocols were employed.

Patients were recruited with informed consent and assessed pre-operatively, then at outpatient clinical review at 6 weeks, 6 months, 1 year and 2 years post-operatively in a clinical testing facility attached to the hospital outpatients department.

Outcomes were contrasted with those of a previously reported study of 212 total knee arthroplasties performed by the same surgeon group[5]. This comparator cohort consisted patients undergoing primary total knee arthroplasty for a diagnosis of osteoarthritis. Cemented, cruciate retaining, fixed bearing implants were used in all cases as per the surgeon's routine practice. This study was chosen as the comparator group as it prospectively evaluated the functional outcomes of a cohort of primary TKAs utilising identical outcome assessments at equivalent time points[5], allowing direct comparison. The consistency in both surgeons and surgical philosophy reduces the influence of potential confounding variables. All source data from the primary TKA study was available to the authors for comparative statistical analysis.

### Outcome assessments

A comprehensive protocol comprising patient reported questionnaires and objective functional assessments was used to evaluate patient outcome. The Oxford Knee Score, a frequently used and well validated 12 item response questionnaire designed to assess the patient's perceived pain and functional ability[6, 7]. Scores range from 0 to 48 with higher values representing better function. Global knee pain severity was assessed using an 11 point (0-10) numerical rating scale (NRS), where 0 represents no pain and 10 the worst possible pain[8]. Patient satisfaction was assessed using a four point Likert response scale; options were very satisfied, satisfied, unsure or dissatisfied, responses were dichotomised to positive response (satisfied or very satisfied) or not.

Active measures of knee flexion were determined using universal goniometry[9]. The ability to perform daily functional tasks was assessed with the aggregated locomotor function score. This score is a composite timed measure of observed locomotor function using tests of walking, stair ascent/descent, and chair transfers; previously demonstrated to be valid, reliable, and responsive[10]. Specifically, patients were asked to walk over a flat eight metre course, ascend then descend a platform consisting of seven fixed steps, and perform a chair transfer task. Time was recorded using a handheld stopwatch (Zeon, UK). Data was collected at all time points.

Outcome data was collected at all assessments except for patient satisfaction, which was evaluated at a single time point (year 2 assessment).

### Statistical analysis

Data for parametric variables are reported by means with standard deviations as a measure of dispersion. Satisfaction data are reported as percentages and were dichotomised to positive or negative values to compare to wider literature[11].

Primary analysis;

Change in outcome parameters over time was assessed with repeated measures ANOVA (general linear models) for longitudinal data with Tukey HSD 95% simultaneous confidence intervals as post-hoc pairwise comparison.

Secondary analysis;

The outcomes achieved in this revision cohort were compared against results achieved a cohort of patients undergoing primary total knee arthroplasty with equivalent assessments using repeated measures ANOVA general linear models, with post-hoc comparisons via Tukey HSD 95% confidence intervals. Analyses were carried out in SPSS version 20. Significance was accepted at  $p=0.05$ .

## RESULTS

### Descriptive analysis

53 patients were recruited to this study in the recruitment period. Three patients were lost to follow-up during the study. One patient died in the year following surgery (cardiac condition), and two stopped attending review clinics/returning correspondence; of these, one was lost to follow-up following 6 week review, and the other following one year review. All data was included in the analysis. The prospective nature of this study allowed for tightly controlled follow-up; as such all assessments are within 8 weeks of planned follow-up, based on time of surgery. Final review assessment was at 24 +/- 2 months.

Mean age of the cohort was 73.23 (SD 10.41) years, 57% were male. Mean time since index surgery was 9.03 years (SD 5.6, data range 1 to 23 years). Mode of failure was dichotomised to diagnoses of aseptic component loosening in 39 (74%) cases and primary component instability in 14 (26%) cases. These represent early and late aseptic failures. Primary implant survival differed between these diagnostic criteria, with a mean time since index surgery of 11.4 years (SD 4.6, data range 7-23 years) in the loosening group and 2.5 years (SD 1.2, data range 1 to 5 years) in the instability group.

The caseload we describe here reflects the range of aseptic revisions that often require significant bony reconstruction; 90% of these cases required distal and posterior femoral augmentation (frequently employing 10mm blocks) and corresponding use of femoral stems. Our surgical technique favours the use of short cemented stems. 'Freshen-up' cuts were often sufficient to address tibial bone loss with only 50% of case requiring augments; however stems were required in every patient. An illustrative example of one of the included cases is provided as pre and post-operative radiographs (figure 1). The specific usage of stems and augments in this cohort is available as supplemental information (table).

### Clinical outcomes

None of these cases were revised within the 2 year follow-up period. There were no readmissions to hospital with complications. Post-operative complications included one clinically diagnosed DVT, where the patient was treated with warfarin, and one transient motor deficit in the common peroneal nerve, which resolved spontaneously, with no further symptoms noted beyond six months post-operation.

### Primary analysis (Triathlon TS revision cohort longitudinal outcomes)

Mean changes in outcomes measures (between pre-op and 2 years post-op) were; 15 point increase in OKS [from 17.6 (SD 7.4) to 32.4 (SD 7.9) points]; 21 degree improvement in knee flexion [80.6 (SD 20.5) to 101.5 (SD 13.2) degrees]; 60% reduction in pain report [7.7 (SD 2.3) to 1.3 (0.4) points]; and 15 second improvement in timed performance assessment [47.2 (SD 19.1) to 32.0 (7.0) seconds] (Table 1).

Longitudinal changes in all 4 outcome measures were statistically significant at  $p < 0.001$  (repeated measures ANOVA) highlighting the positive effect of revision arthroplasty on the patient's pain and physical function (Figures 2-5). Post-hoc analysis demonstrated statistically significant differences between early assessment points (pre-op, 6 week and 26 weeks post-op) across all four outcome parameters, further changes over time were not statistically different to the 6 month time point.

Patient reported post-operative satisfaction with revision knee arthroplasty at 2 years was 84%, Table 2. Of the three patients that reported dissatisfaction with outcome, two highlighted continuing pain and one highlighted post-operative complications as reasons for their response.

### Secondary analysis (comparison to primary TKA outcomes)

Outcome data for this revision cohort was contrasted with that of a previously reported cohort of 212 primary total knee arthroplasty patients performed by the same surgeons with identical outcome assessments at equivalent time points[5] (Table 3).

Secondary analysis compared the revision cohort to the primary knee arthroplasty data. The revision cohort was 5 years older [primary cohort 68.3 (9.0) years, paired t-test,  $p = 0.01$ ] with a higher proportion of males [primary cohort 32% male, Chi Square,  $p = 0.037$ ].

No difference was observed between primary and revision groups in OKS (repeated measures ANOVA  $p = 0.2$ ). Post hoc assessment demonstrated a similar trajectory of change with overlapping confidence intervals at individual assessment time points (Figure 2). Similarly, no between group difference was observed in pain scores (repeated measures ANOVA,  $p = 0.19$ ) (Figure 3).

Range of motion was significantly different between groups over the 2 year assessment period (repeated measures ANOVA,  $p = 0.03$ ), however this was due to the notably poorer pre-operative flexion scores in the revision cohort. Post-hoc analysis showed that there was no difference between groups in flexion at any post-operative time point (Figure 4), and that the revision cohort achieved the same flexion parameters as the primary group. Similarly, though there were statistically significant between group differences in timed performance test across the assessment period (repeated measures ANOVA,  $p = 0.02$ ), however this was driven by the pre-operative value being notably worse in the revision group. Post-operatively there was no difference in functional performance time (Figure 5).



**DISCUSSION:**

This study highlights high levels of functional performance in a consecutive cohort of aseptic revision total knee arthroplasty patients in the initial 2 years following surgery. Post-operative outcomes were seen equivalent to those following primary knee arthroplasty in terms of range of motion, pain report, patient reported outcome score and timed functional performance.

Revision knee arthroplasty is, generally, a costly and complex intervention that requires considerably more resources than the index surgery[12]. Although improvements are reported in patient health and function, outcomes of revision knee arthroplasty are accepted as being worse than those of primary procedures[3, 13]. The outcomes of revision knee arthroplasty are particularly difficult to quantify as the 'level' of revision procedure is not always clear, and results differ according to mode of failure, with outcomes following septic revision notably worse[3, 14]. From an implant perspective, revision knee replacement ranges from fairly minor procedures such as secondary patella resurfacing or liner exchange, through to constrained linked and mega-protheses, and patient outcomes will likely reflect the indications for surgery. There is a distinct lack of functional outcome data available in the wider literature with which to evaluate patient recovery following revision knee arthroplasty beyond implant survival statistics, rates of surgical complications and registry data[4]. In possibly the most comprehensive paper to date, Baker et al[3] report an analysis using data from the UK National Joint Registry and demonstrate revision cases to perform worse than primaries as assessed with patient reported data (the Oxford Knee Score and satisfaction score) at 12 months. Lesser satisfaction is a typical report following revision surgery; Baier et al.[15] reported a 28% complication rate and 26% re-operation rate in a series of 78 revision knees. Notably, these authors reported that 28% of patients would not have chosen revision surgery if they could 'go back in time and decide again'.

As such, the data we report here is of interest as it both charts the patients' post-operative recovery in the 2 years following revision surgery and contextualises this against that of primary knee replacement using comparable data at equivalent time points. Interestingly the average pain report and Oxford Knee Score were equivalent between primary and revision cases pre-operatively, suggesting a similar level of symptomology prior to surgery, however range of motion and timed performance tasks were notably worse pre-operatively amongst the revision group, suggesting a greater physical dysfunction. Despite this 'lower' starting point, similar improvements in all parameters were observed longitudinally in the 2 years following surgery in both primary and revision groups; the overlapping confidence intervals reflecting the statistical equivalence of the data at the post-operative assessment time points. 84% of patient in this revision series reported being either satisfied or highly satisfied with the outcome, a figure that is also directly comparable to typical reports following primary knee arthroplasty[11, 16].

The majority of improvement (across all assessed parameters) was seen in the early post-operative period. Significant improvements were recorded between pre-op and 6 weeks and between 6 weeks and 6 months post-op, with no further relevant functional changes over time. This is somewhat in contrast to the typical clinical assertion that post-operative recovery is a slow process. Our data instead suggests that a comparatively rapid physical recovery and reduction in pain symptoms can be achieved at the earliest clinically relevant post-operative time points in this patient group.

**Strengths and limitations**

To our knowledge this is the most detailed post-operative functional analysis of a multi-surgeon series of semi-constrained revision implants to date. There are many strengths to this study, including the prospective repeated measures methodology, length of longitudinal follow-up, depth of the functional assessments performed and the consistency of surgical protocol. All four surgeons perform high volumes of revision knee arthroplasty[16] and employed the same surgical philosophy and technique. This consistency allows us to report average functional outcomes of this cohort of aseptic revision knee arthroplasties performed with total stabilizer implants; however the results may not necessarily translate to other techniques, implants or situations. A further limitation is the restricted post-operative timeframe of 2 years, which allows us to comment on the early post-operative function achieved by patients, but not on implant survival.

## Conclusions

Patients undergoing revision TKA with semi-constrained total stabiliser implants made substantial improvements in OKS, pain scores, knee flexion, and timed functional performance in the initial 2 years following surgery. The early functional results achieved are remarkably similar to those reported for primary arthroplasty, highlighting that high levels of patient function can be achieved following revision knee arthroplasty using semi-constrained devices. This finding is important in relation to the projected high volumes of revision surgery over the next 2 decades, potentially in relatively 'young' patients with higher expectations of functional ability in their older years.

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# TABLES

**Table 1 – revision cohort longitudinal outcomes (mean, SD)**

|                        | Pre-op        | 6 weeks       | 26 weeks       | 52 weeks       | 104 weeks      |
|------------------------|---------------|---------------|----------------|----------------|----------------|
| OKS                    | 17.55 (8.82)  | 25.23 (10.89) | 29.50 (11.84)  | 30.18 (11.55)  | 32.39 (10.39)  |
| Pain scale             | 7.67 (2.29)   | 4.54 (2.25)   | 2.76 (2.63)    | 2.23 (2.72)    | 1.33 (2.08)    |
| Range of motion (deg)  | 80.60 (20.54) | 93.85 (18.43) | 102.62 (15.61) | 101.78 (18.09) | 101.52 (13.15) |
| Functional tasks (sec) | 47.22 (19.08) | 30.91 (7.87)  | 32.96 (7.24)   | 32.35 (8.74)   | 32.00 (6.97)   |

**Table 2 - patient reported satisfaction at 2 years post-surgery (n=50)**

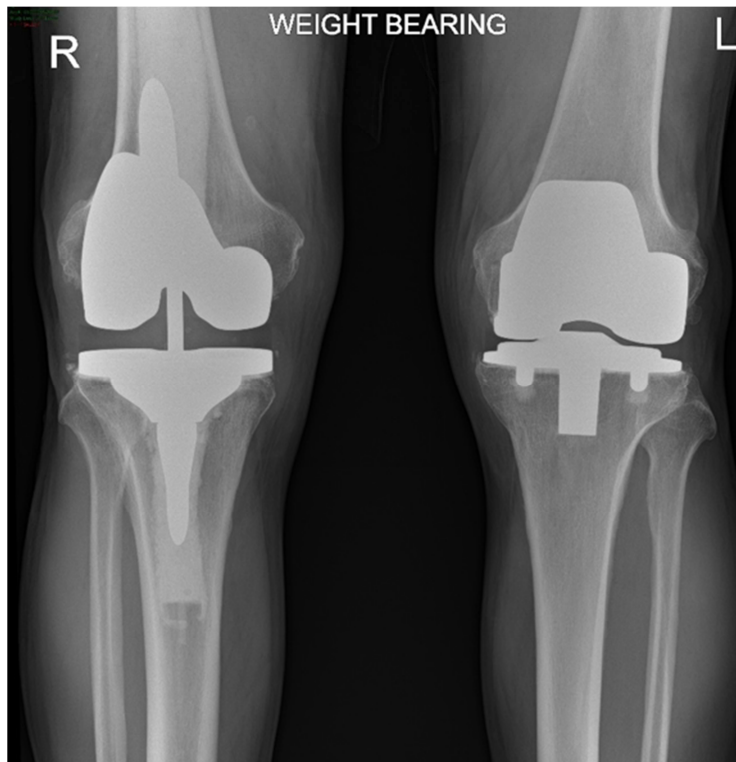
|           | Very satisfied | Satisfied | Unsure  | Dissatisfied | Very dissatisfied |
|-----------|----------------|-----------|---------|--------------|-------------------|
| Cases (%) | 19 (38%)       | 23 (46%)  | 5 (10%) | 3 (6%)       | 0 (0%)            |

**Table 3 – comparator data for primary TKA (mean, SD)**

|                        | Pre-op         | 6 weeks       | 26 weeks       | 52 weeks       | 104 weeks      |
|------------------------|----------------|---------------|----------------|----------------|----------------|
| OKS                    | 19.1 (7.41)    | 27.4 (8.86)   | 34.9 (8.25)    | 37.8 (7.89)    | 36.4 (8.17)    |
| Pain scale             | 8.27 (1.46)    | 5.36 (2.55)   | 2.99 (2.70)    | 2.34 (2.57)    | 1.69 (2.16)    |
| Range of motion (deg)  | 104.85 (14.40) | 96.31 (13.25) | 104.30 (12.40) | 107.36 (11.76) | 104.17 (10.11) |
| Functional tasks (sec) | 35.41 (14.32)  | 31.67 (11.50) | 26.56 (7.78)   | 25.61 (6.60)   | 26.62 (5.50)   |

**FIGURES****Figure 1 – illustrative radiograph of TS revision for aseptic failure****Panel A – pre-operative AP****Panel B – pre-operative lateral**

302 **Panel C – post-operative AP**



305 **Panel D – post-operative lateral**



Figure 2 – OKS (comparators with 95%Cis)

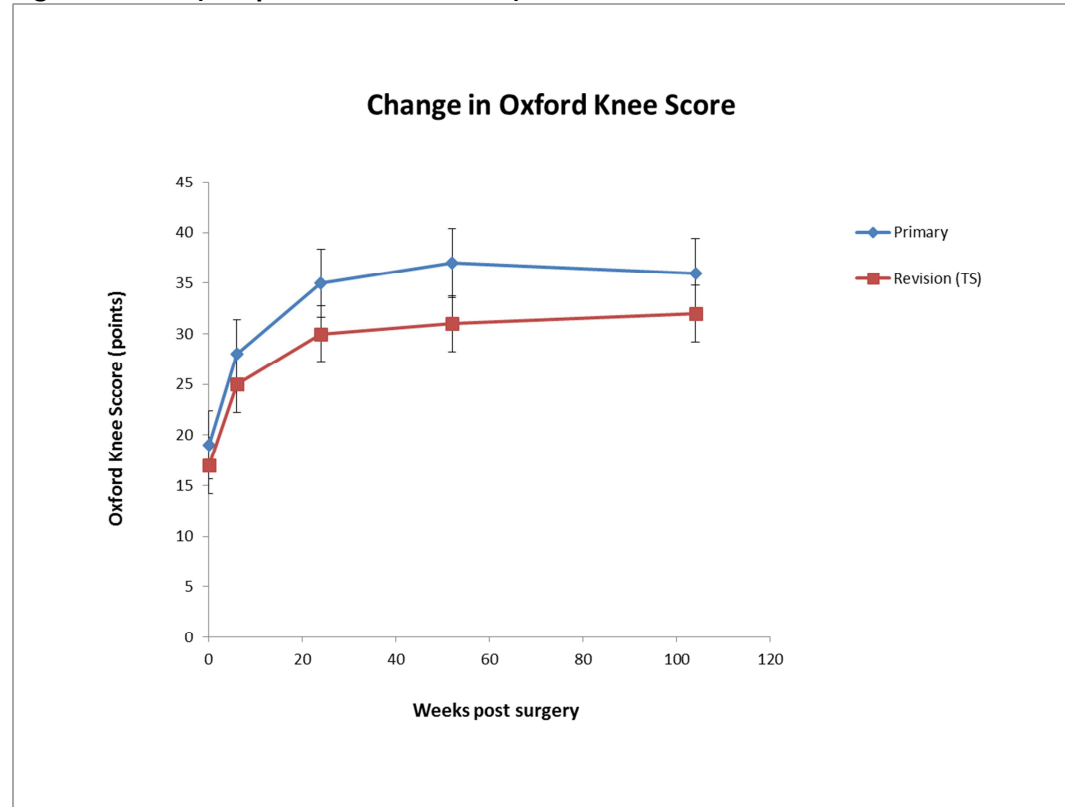
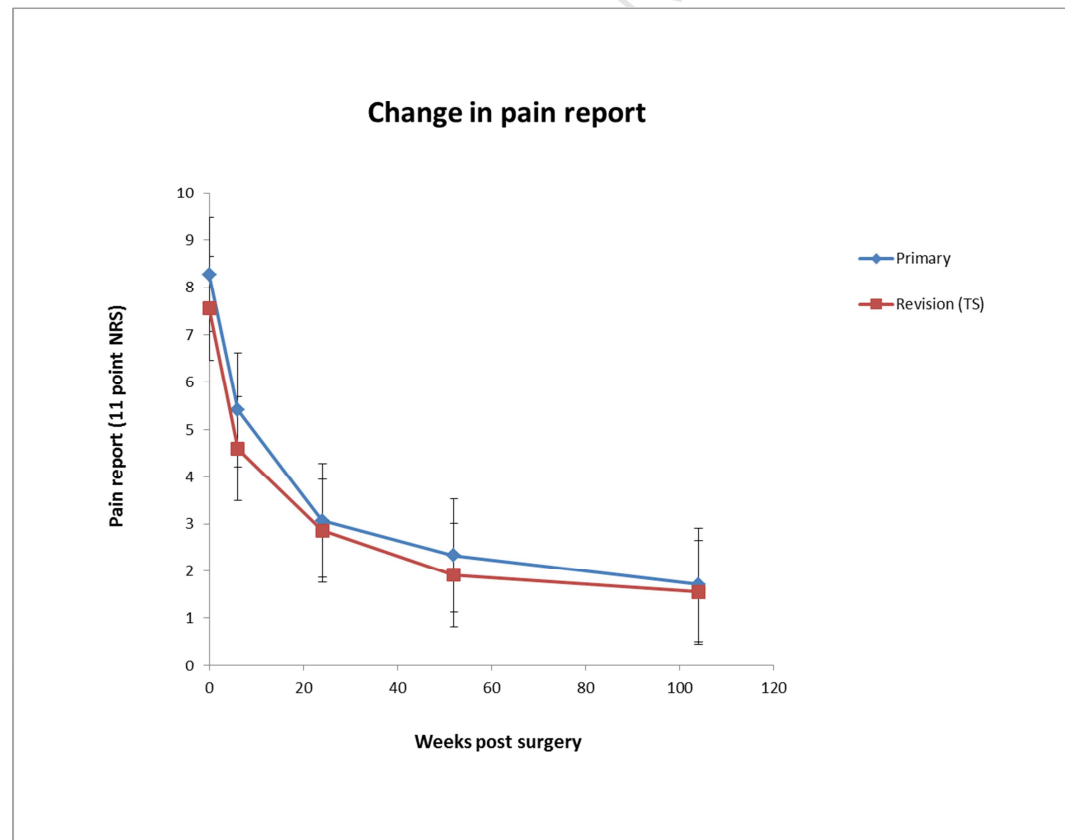
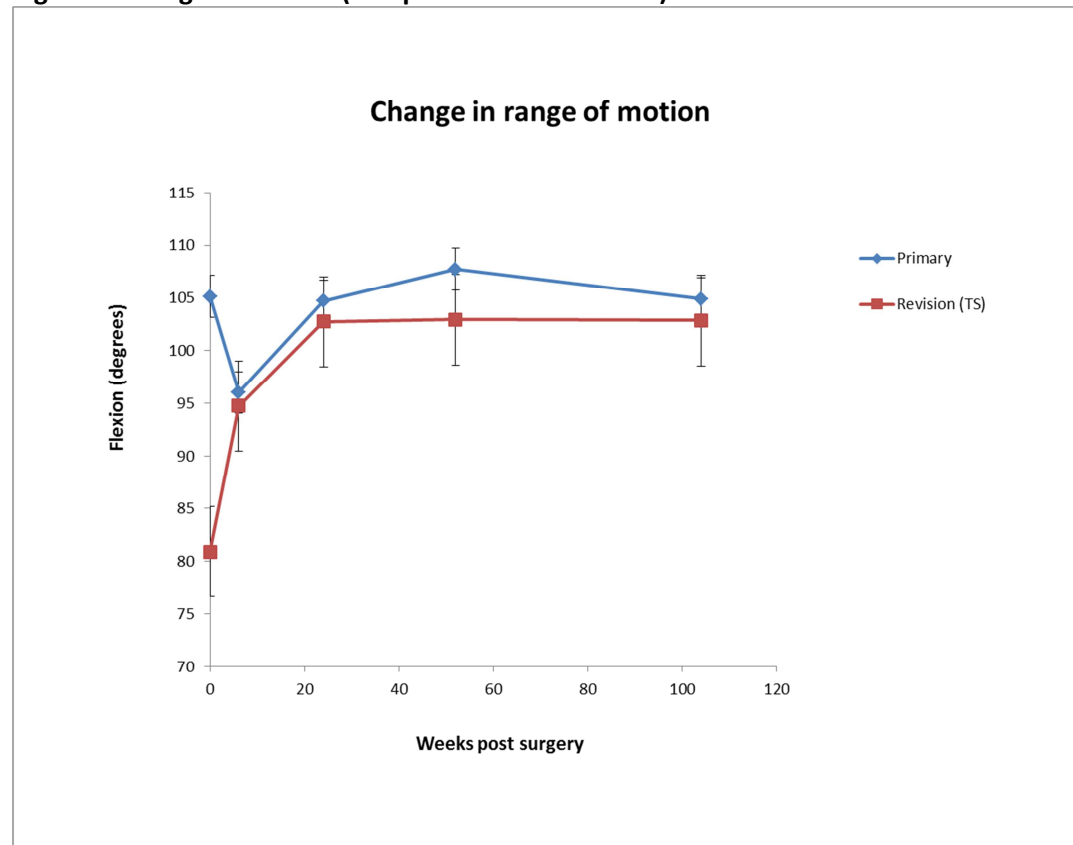


Figure 3 – pain scores (comparators with 95%Cis)



**Figure 4 – range of motion (comparators with 95%Cis)**



**Figure 5 – timed functional performance (comparators with 95%Cis)**





## Supplemental information

## Supplemental Table – Augments and stems used (% cases)

|              | Stem<br>(mm) | Cases | Distal<br>(mm) | Cases | Posterior<br>(mm) | Cases |
|--------------|--------------|-------|----------------|-------|-------------------|-------|
| <b>Femur</b> | 0            | 5%    | 0              | 10%   | 0                 | 10%   |
|              | 50           | 65%   | 5              | 50%   | 5                 | 30%   |
|              | 100          | 30%   | 10             | 30%   | 10                | 60%   |
|              |              |       | 15             | 10%   |                   |       |
|              |              |       |                |       |                   |       |
| <b>Tibia</b> | 0            | 0%    | 0              | 50%   |                   |       |
|              | 50           | 75%   | 5              | 15%   |                   |       |
|              | 100          | 25%   | 10             | 35%   |                   |       |